PATENT SPECIFICATION

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COMPLETE SPECIFICATION

Improvements relating to the Testing of Screw Threads

We, METROPOLITAN - VICKERS ELECTRICAL COMPANY LIMITED, of St. Paul's Corner, 1—3, St. Paul's Churchyard, London, E.C.4, a British Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a method of testing screw threads in which the technique of light interferometry is employed to enable a higher degree of accuracy to be obtained in the shaping of the thread than has been possible heretofore.

The present invention contemplates that the surface of the screw thread being tested as viewed by reflection or refraction from a special auxiliary surface shall be compared with a standard reference surface of an interferometer so that any departure of the screw surface from the desired figure will be revealed by the production of light fringe patterns.

According to the present invention such comparison is effected by an adaptation of the Michelson interferometer in which the screw thread to be tested is arranged in substitution for one of the usual plane test surfaces, with its axis parallel to the optical axis, and the surface of the thread is viewed by reflection from an auxiliary surface which is itself generally screw shaped in form and is so shaped and arranged that the surface of the screw as seen by the instrument appears substantially plane and may thus be compared with the other plane surface of the interferometer.

The auxiliary surface or screw may be arranged as a nut, spaced from the screw to be tested and accurately set up so as to be coaxial therewith, the surfaces of the screws being so formed that light parallel with the common axis reflected from the surface of the auxiliary screw on to the surface of one or more turns of the screw to be tested will be reflected back to the surface of the auxiliary screw and thence along the axis towards the source, the path length to all parts of the surface of the screw under inspection being constant.

In carrying the invention into effect it is desirable to ensure that the surface of the auxiliary screw shall be of such shape that it can reasonably be formed as accurately as possible by available technique. According to an important feature of the present invention the surfaces of the auxiliary screw and of the screw to be tested are both shaped according to a law determined by the following considerations.

Considering a point P on the circumference of a section through a screw normal to the axis and denoting the angle of descent of the thread at the circumference by α, then the pitch distance of the screw $P = 2\pi R \tan \alpha$ where R is the radial distance of the point P. For a small distance δl along a line through P in the plane of the section and in the direction of the steepest descent of the thread there will occur a descent $\delta l \tan \beta$ where β is the angle of steepest descent. This descent $\delta l \tan \beta$ is equal to $\delta l \sec \theta \tan \alpha$ where θ is the angle between the said line and the tangent at P and is also the angle between the normal from the centre O to the said line and the radius through P; the length of the normal may be represented by ON and is termed the skew distance.

From the above we have

$$\tan \beta = \sec \theta \tan \alpha = \frac{P \sec \theta}{2\pi R} = \frac{P}{2\pi R \cos \theta} = \frac{P}{2\pi . ON}$$

This expression defines a screw shape

[Price 2/8] Price 4s 6d

and also indicates how it may be cut by the application of ordinary screw cutting methods. In the screw for this invention, however, β will not, as is usual, be made a function of R but will be independent of R.

If we now take two such screws having constants $\beta_1 P_1$ ON_1 and $\beta_2 P_2$ ON_2 and make

$$\beta_2 = \frac{1}{2}\beta_1 \text{ or } = \frac{1}{2}(\beta_1 + \pi)$$

and $ON_2 = ON_1$

then $$\frac{P_1 \tan \beta_2}{P_2 \tan \beta_1} = \frac{ON_2}{ON_1} = 1$$

so that we have

$$\beta_2 = \frac{1}{2}\beta_1, \text{ and } \frac{P_1}{P_2} = \frac{\tan \beta_1}{\tan \beta_2}$$

Now for two such screws arranged coaxially, in plan every normal to screw 1 will coincide with a normal to screw 2 and similarly the lines of steepest descent will also coincide. Accordingly light parallel to the common axis of the two screws will be reflected from the surface of one to the surface of the other and back again to the source as though the two surfaces were a single plane surface.

In order that the invention may be clearly understood reference will now be made to the accompanying drawing, in which:—

Fig. 1 shows diagrammatically the arrangement of a screw thread to be tested in relation to an interferometer of the Michelson type;

Fig. 2 shows on an enlarged scale and as a half axial section the screw thread and auxiliary screw shaped test surface of Fig. 1; and

Fig. 3 shows an alternative form of the auxiliary screw surface.

Referring to Figs. 1 and 2, the Michelson interferometer there shown comprises a light source 1 with a collimating lens 2 providing a beam of light of narrow angle which is in part reflected from a half silvered surface 3 on to a reference surface 4 and in part transmitted through the half silvered surface 3 to fall on the auxiliary screw shaped surface 5 from which it is reflected on to the screw surface 6 to be examined. The configuration of the auxiliary surface 5 in relation to the surface 6 is such that light from the source reflected from the auxiliary surface 5 on to the screw surface 6 will be reflected back again on to the auxiliary surface and thence along the axis towards the source, the path length to all parts of the surface 6 under observation being constant. The arrangement of the auxiliary surface 5 and the screw surface 6 thus forms an image of the surface of the screw surface 6 which, apart from imperfection of this surface, is plane and may therefore be compared with the reference surface 4. Accordingly by observation at the point 7, preferably with the aid of an observing telescope consisting of a lens or lens system arranged to image the light source 1 into the eye pupil and the surface of the screw 6 to a distance convenient for observation, the image of the screw surface 6 and the image of the reference surface 4 may be seen superposed, when if the reference surface is optically flat any departure from the desired shape of the screw surface will be revealed as light fringes.

In practising the invention, the screw to be tested, which has preferably been cut in accordance with the above mentioned considerations, will be arranged as shown in Fig. 1 within and coaxially with an auxiliary screw surface 5 which is arranged as a nut spaced from the screw to be tested and which is also preferably cut in accordance with the above-mentioned considerations. As shown more clearly in Fig. 2 the auxiliary screw 5 preferably consists of one or slightly more than one turn, and the width of the flank in section may be such as to enable one or more than one turn of the screw to be tested to be seen when viewed in an axial direction.

With the auxiliary screw extending over one turn and having a wide flank, a number of turns of the screw under test may be observed and will be seen as a spiral but with a discontinuity at the end of each turn.

The auxiliary screw may, however, be formed as shown in Fig. 3 with more than one turn, the several turns 8 being arranged for example conically so that they do not obstruct light reflected from each other, and if the projection of the flank of the screw under test on the surface of the auxiliary screw has a width less than the one turn's radius increment of the auxiliary screw, the successive turns of the screw under test may be seen as a continuous non-overlapping spiral in plan.

With the combined screws set up in position to form one of the reflecting surfaces of a Michelson interferometer, any irregularities of the two surfaces as compared with a standard plane reflecting surface will be revealed by light fringes in the normal manner, and by a suitable technique involving relative rotation of the two screws irregularities on either of the screw surfaces may be identi-

fied and removed by polishing or other suitable methods in known manner.

What we claim is:—

1. The method of testing the accuracy of a surface of a screw thread, in which the screw thread is set up in a Michelson type interferometer in substitution for one of the usual plane test surfaces and with its axis parallel with the optical axis, the surface of the thread is viewed by reflection from an auxiliary surface which is itself generally screw shaped in form and is so shaped and arranged as to produce a substantially plane image of the screw thread which may be compared with the other plane surface of the interferometer.

2. The method of testing the accuracy of a surface of a screw thread as claimed in claim 1, in which both the auxiliary surface and the surface of the thread to be tested are shaped in accordance with the mathematical considerations set forth herein so that in plan every normal to one surface will coincide with a normal to the other surface.

3. In or for use in the testing of the accuracy of a surface of a screw thread by the method claimed in claim 1, an auxiliary screw shaped reflecting surface constructed and arranged substantially as herein described with reference to the accompanying drawing.

4. The method of testing the accuracy of a surface of a screw thread by interferometry substantially as herein described.

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PROVISIONAL SPECIFICATION

Improvements relating to the Testing of Screw Threads

We, METROPOLITAN-VICKERS ELECTRICAL COMPANY LIMITED, of St. Paul's Corner, 1—3, St. Paul's Churchyard, London, E.C.4, a British Company, do hereby declare the nature of this invention to be as follows:—

This invention relates to a method of testing screw threads in which the technique of light interferometry is employed to enable a higher degree of accuracy to be obtained in the shaping of the thread than has been possible heretofore.

The present invention contemplates that the surface of the screw thread being tested, as viewed by reflection or refraction from a special auxiliary surface, shall be compared with a standard reference surface of an interferometer so that any departure of the screw surface from the desired figure will be revealed by the production of light fringe patterns.

In one form of the invention such comparison is effected by an adaptation of the Michelson interferometer in which the screw thread to be tested is arranged, in substitution for one of the usual plane test surfaces, with its axis parallel to the instrument axis, and the surface of the thread is viewed by reflection from an auxiliary surface which is itself generally screw shaped in form and is so shaped and arranged that the surface of the screw as seen by the instrument appears substantially plane and may thus be compared with the other plane surface of the interferometer.

The auxiliary surface or screw may be arranged as a nut, spaced from the screw to be tested and accurately set up so as to be coaxial therewith, the surfaces of the screws being so formed that light parallel with the common axis reflected from the surface of the auxiliary screw on to the surface of one or more turns of the screw to be tested will be reflected back to the surface of the auxiliary screw and thence along the axis towards the source, the path length to all parts of the surface of the screw under inspection being constant.

In carrying the invention into effect it is desirable to ensure that the surface of the auxiliary screw shall be of such shape that it can reasonably be formed as accurately as possible by available technique. According to an important feature of the present invention the surfaces of the auxiliary screw and of the screw to be tested are both shaped according to a law determined by the following considerations.

Considering a point P on the circumference of a section through a screw normal to the axis and denoting the angle of descent of the thread at the circumference by α, then the pitch distance of the screw $P = 2\pi R \tan \alpha$ where R is the radial distance of the point P. For a small distance δl along a line through P in the plane of the section and in the direction of the steepest descent of the thread there will occur a descent $\delta l \tan \beta$ where β is the angle of steepest descent. This descent $\delta l \tan \beta$ is equal to $\delta l \sec \theta \tan \alpha$ where θ is the angle between the said line and the tangent at P and is also the angle between the normal from the centre O to the said line and the radius through P; the length of the

normal may be represented by ON and is termed the skew distance.

From the above we have

$$\tan\beta=\sec\theta\tan\alpha$$
$$=\frac{P\sec\theta}{2\pi R}$$
$$=\frac{P}{2\pi R\cos\theta}$$
$$=\frac{P}{2\pi.ON}$$

This expression defines a screw shape and also indicates how it may be cut by the application of ordinary screw cutting methods. In the screw for this invention, however, β will not, as is usual, be made a function of R but will be independent of R.

It we now take two such screws having constants $\beta_1 P_1 ON_1$ and $\beta_2 P_2 ON_2$ and make

$$\beta_2=\frac{1}{2}\beta_1 \text{ or } =\frac{1}{2}(\beta_1+\pi)$$

and $ON_2=ON_1$

then $$\frac{P_1\tan\beta_2}{P_2\tan\beta_1}=\frac{ON_2}{ON_1}=1$$

so that we have

$$\beta_2=\frac{1}{2}\beta_1, \text{ and } \frac{P_1}{P_2}=\frac{\tan\beta_1}{\tan\beta_2}$$

Now for two such screws arranged coaxially, in plan every normal to screw 1 will coincide with a normal to screw 2 and similarly the lines of steepest descent will also coincide. Accordingly light parallel to the common axis of the two screws will be reflected from the surface of one to the surface of the other and back again to the source as though the two surfaces were a single plane surface.

In practising the invention, the screw to be tested, which has been cut in accordance with the above considerations, will be arranged within and coaxially with an auxiliary screw which is arranged as a nut spaced from the screw to be tested and which is also cut in accordance with the above considerations. The auxiliary screw preferably consists of one or slightly more than one turn, and the width of the flank in section may be such as to enable one or more than one turn of the screw to be tested to be seen when viewed in an axial direction.

With the auxiliary screw extending over one turn and having a wide flange, a number of turns of the screw under test may be observed and will be seen as a spiral but with a discontinuity at the end of each turn.

The auxiliary screw may, however, be formed with more than one turn, the several turns being arranged for example conically so that they do not obstruct light reflected from each other, and if the projection of the flank of the screw under test on the surface of the auxiliary screw has a width less than the one turn's radius increment of the auxiliary screw, the successive turns of the screw under test may be seen as a continuous non-overlapping spiral in plan.

With the combined screws set up in position to form one of the reflecting surfaces of a Michelson interferometer. any irregularities of the two surfaces as compared with a standard plane reflecting surface will be revealed by light fringes in the normal manner, and by a suitable technique involving relative rotation of the two screws irregularities on either of the screw surfaces may be identified and removed by polishing or other suitable methods in known manner.

Dated the 26th day of May, 1949.

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673,971 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale.*

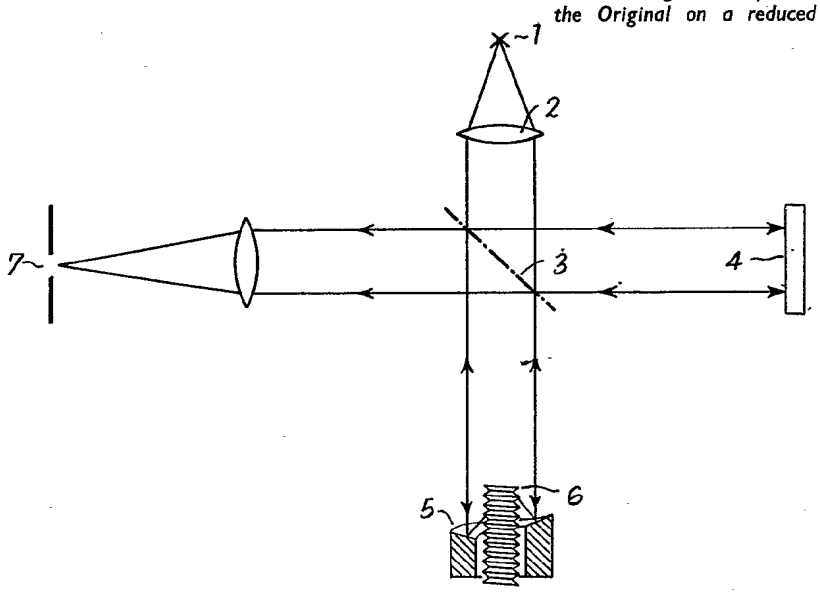

FIG.1.

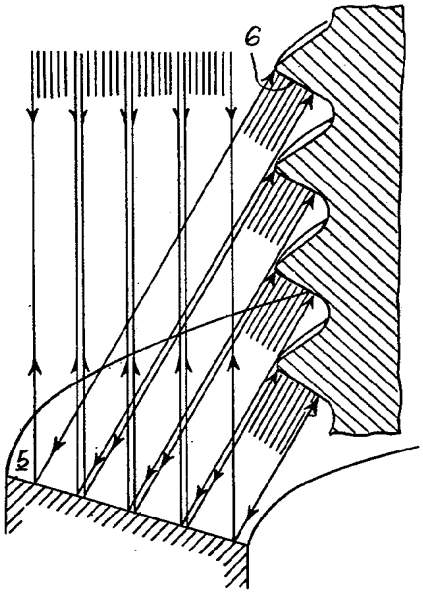

FIG.2.

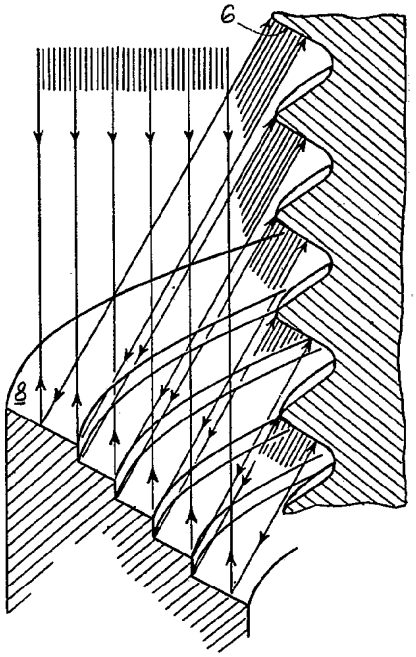

FIG.3.

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